WORKING PAPER
ALFRED P. SLOAN SCHOOL OF MANAGEMENT

Government Funding Strategy in Technology Programs

Jong-Tsong Chiang

January 1990

WP 3129-90-BPS

MASSACHUSETTS
INSTITUTE OF TECHNOLOGY
50 MEMORIAL DRIVE
CAMBRIDGE, MASSACHUSETTS 02139

Government Funding Strategy in Technology Programs

Jong-Tsong Chiang

January 1990 WP 3129-90-BPS

1. The author is grateful to the International Institute for Applied Systems Analysis (IIASA) and several organizations in Europe for their financial support and other assistance in doing the field research concerning this topic in a number of European countries.

2. This paper is to appear in *Technological Forecasting and Social Change* (forthcoming, 1990).

Government Funding Strategy in Technology Programs

Abstract

Industrial R&D in a market economy is mainly implemented in private sector, therefore public funding is a very important tool of government to guide private R&D activities. This paper investigates the experience of funding national programs in a number of industrialized countries, and reaches some preliminary conclusions:

1. To reduce opportunistic behavior and ingrain intrinsic incentive in firms, both competition and cost sharing principles should be used concurrently in underwriting firms' R&D projects.

2. Competition principles can be applied across many candidate projects around the same time or a series of one-of-a-kind projects over longer time horizon.

3. The major threat to application of competition principles is that there is no "real competition" due to few qualified candidates in specific technological fields or in some, especially small, countries.

4. In practice, the appropriate cost sharing level is difficult to determine. 50-50 is used as a rule of thumb in many countries to simplify the decision making and circumvent "bounded rationality."

5. Full cost endorsement may be another "quantum" alternative for projects urged by government but not felt to be very relevant by firms.

Introduction

The 1980s witnesses a proliferation of national and international technology development programs (referred to hereafter simply as national or international programs) aiming at enhancing industrial competitiveness. One of these programs' main features is to emulate Japan's strategy of its VLSI Project in the late 1970s and to encourage industrial collaborative R&D. For most countries and even international bodies, public funding becomes the most important tool in this endeavor because in a market economy industrial R&D is mainly implemented by private firms. Therefore the funding strategy in these programs warrants special attention. Nevertheless, it is normally very difficult to make an accurate estimate of the financial support of government in R&D activities because of different categorization of budget, indirect support by means of tax credits and other subsidies, etc. In this research, the focus is only on the underlying rationale and strategy, rather than the absolute level, of government direct funding to industrial R&D projects in national programs.

Principles in Government Funding

Among others, government usually has to do three things in a national program. First it should avoid spreading resources too thinly and instead concentrate them on some priority technology fields. Second, it should identify high caliber teams to undertake the task.

Third, it should ensure good implementation. Government funding strategy has to help attain these goals.

To encourage industry to pursue innovation in some prescribed directions, government can provide funds to share R&D cost. But too high commitment to some projects may be very costly and risky. This is usually done at the expense of other alternatives which may also have good potential, thus reducing the number of solution routes pursued and even chance of success.[1] Too much subsidy from government may also entice firms to propose ideas and execute missions carelessly. Moreover, government may overlook signals and needs from industry and industry may not bother to reflect their opinion if industry has no part in the funding.

To select better teams, government can adopt a screening process based on competition in one way or another among candidates. This strategy hopefully can also help reduce conscious or unconscious opportunism.[2] But it also has some limitations. One is that too much competition may make opportunism more likely and responsible behavior more difficult to afford.[3] Another is that "real competition" may not exist if there are few qualified candidates in some technological fields. Then the "moral hazard" due to "small number" situation may arise.[4]

To ensure responsible implementation, government can monitor the progress. But most R&D activities, except physical demonstration projects, are difficult to evaluate objectively. Furthermore, most concerned contracts are rather incomplete and full of uncertainty

because of the nature of R&D. Therefore opportunistic behavior may be unobservable or not easy to detect. In other words, government in reality cannot do much if firms are not strongly committed to the job.

To compensate for the potential pitfalls as indicated above, government can make its funding contingent on the firms' commitment of their own stake. It has good reason to hypothesize that, the more the firms invest their own resources, the more "serious" and "honest" they will be. In this way, firms have "intrinsic" incentive to do good job for their own sake. However, the appropriate cost sharing formulae between government and firms still remain to be decided. In principle, government would be willing to share more cost the higher the spill-over effects or externalities. For firms, the opposite rationale applies. They would commit more resources the higher the appropriability of the projects. But both sides may not agree with each other. And firms' actual financial expenditure is not easy to strictly monitor.

In many national (and EC international) programs, collaboration is a necessary condition for getting subsidy. Government funding thus becomes a bait for collaboration especially between real or potential competitors, which may otherwise not occur at all. This additional purpose makes it more difficult at least in theory to determine an appropriate funding level.

Application of Competition Principle and Limitations

In the real world, competition based on the evaluation of proposals is basically followed by most West European countries investigated in this research: the U.K., Sweden, Norway, Finland, and the Netherlands. This is also Germany's long tradition of government support of industrial R&D. However, to prepare a qualified proposal requires some threshold effort. This process in effect rules out many small firms with little technical reservoir. Once a project is started, it is quite difficult to stop except for very obvious reasons like the termination of firms.[5] However, some evidence shows that many firms actually spent more money than they originally claimed to, because their projects were connected to their central business and many new research topics were stimulated after some time of work.[6]

As predicted, for some technological areas, there are few qualified firms, and real competition does not exist. Examples include semiconductor hardware projects in most countries, conventional materials programs in Norway and Finland, and forest-related technology programs in Finland. The main reasons are as follows. In semiconductor hardware technology, entry threshold is very high and presently there are only a small number of firms in this industry. In other more traditional technology programs which need rather concentrated and big investment, there are only a few large established firms in small countries.[7] In some other cases where there is little enthusiasm from industry, government even has to persuade firms to participate in the national programs, work with them on

proposal preparation, and arrange special support from public R&D institutes.

In Japan, the principle of competition is applied in a different way. Government intention to support oligopolistic IT (information technology) firms to compete in the global market made it bet on a small number of "potential winners." So the initial selection of firms was not really competitive. But a series of consecutive national projects since the 1960s gave government a chance to better compare and monitor participants' competence and commitment. As a striking example, when Oki failed to come out with a commercial product in the New Series Project in response to IBM 370 series, the Ministry of International Trade and Industry (MITI) decided to exclude it from the next VLSI Project. Therefore competition principle works over time.

By contrast, France, a country with strong tradition of government guidance and direct involvement in technology development, overlooked this principle and adopted "single national champion strategy" in many fields, e.g., one firm in computers and another one in semiconductors. It is argued that, among others, the lack of competition pressure helps explain France's failure in developing a viable semiconductor and computer industry.[8]

Application of Cost Sharing Principle and Bounded Rationality

As to government funding level, it is not surprising that, except some cases, most governments, and even EC Commission, adopted cost-sharing policy in projects mainly executed by firms. In Denmark, the government financial backing is about 40-45% including prototype and pilot projects; in Sweden, Finland and the Netherlands, about half; in the U.K., the original plan of varying percentage depending on the nature of individual projects and of 60% on the average was reduced to 50% across-the-board; in FRG, a long tradition of less than half; and in most EC programs (e.g., ESPRIT, RACE, BRITE and EURAM), 50%. But in Japan, the situation was more complex: approximately 50% in FONTAC, 100% in Super High Performance Computer, 100% in Pattern Information Processing System (PIPS), 50% in New Series, 40% in VLSI, and 100% in Fifth Generation Computer.

The above evidence suggests that it is quite difficult in real practice to determine project by project the appropriate cost-sharing level. So to roughly split the cost evenly between government and industry is the "most convenient" way under normal conditions.[9] It therefore becomes a rule of thumb in many countries, and simplifies the delicate issues to be dealt with by "bounded rationality."[10] However, when the tasks are extraordinarily difficult relative to the firms' capabilities, have little immediate impact on the firms' competitiveness, or embrace high likelihood of large externalities, government tends to endorse the whole cost. Japan's exceptional experience in Super High Performance Computer, PIPS and Fifth

Generation Computer Programs as discussed in more details below seems to support this second alternative.

Rationale of Full Funding in Japan

In Japan, PIPS was an add-on project in 1971 after the recognition of the special weakness in handling Japanese language programming, printing and data transmission in the previous Super High Performance Computer Project. PIPS was highly technical and began in 1971 without a true understanding of its implications or complexity by the various MITI councils and advisory groups. It proved to be an extremely difficult set of tasks, considering the general development level of input-output devices at the time. Government sponsored the whole cost in this project, but the budget was then reduced from ¥35 billion to ¥22 billion, and the execution was extended two more years from the planned eight years. Upon its completion, PIPS did not meet any real commercial marketing criterion. The evaluation was mixed, depending on different standpoints. One study said MITI considered PIPS as a whole to be a failure but with some technical successes.[11] U.S. OTA gave it relatively high remarks for its long-term impact including laying groundwork for the later Fifth Generation Computer Program.[12] Regardless of its actual outcomes, Japan's government found it very difficult to persuade industry to pool funds for PIPS.

In the Fifth Generation Computer Program, the ultimate goal is to develop a radically new kind of computer based on revolutionary

breakthroughs in computer architecture and artificial intelligence. If it is successful to a reasonable degree, it may put Japan at the leading edge of computer and information technology, a step further from its present strong microelectronics and the fourth generation computer position. In fact, MITI's attempt in this program is a natural extension of its long-term series of national initiatives. It also aims at stimulating creativity and original innovation, which until recently are not deemed as Japanese strength. However, private industry was reluctant to commit half of the planned total budget ¥100 billion to such vague and seemingly unrealizable goals. The Ministry of Finance also refused to make up the difference which was supposed to be covered by industry. As a result, MITI ended up being solely responsible for the total funds ¥50 billion as promised.[13]

For the Super High Performance Computer Project, the rationale for government 100% support is not clear according to the information available. But there are some clues. Its predecessor FONTAC launched in 1962 was widely perceived as a failure. The parts developed by Fujitsu, Oki and NEC did not connect properly, and the machine could not run.[14] Meanwhile, IBM in 1964 introduced its much more powerful 360 series. This serious situation triggered this national project in 1966 to quickly respond to IBM's new threat, and its membership increased to include all six major manufacturers. It might be due to this urgent condition that MITI decided to fully underwrite the Super High Performance Computer Project.

Concluding Remarks

In national programs, government assumes a direct developmental (as opposed to regulatory) role. But in general industry has better knowledge about the commercial prospects of a technological innovation than government. This information asymmetry is an important cause of failure in many government-led technology programs.[15] If the "government failure," typified by the intrusion of vested interest groups like politicians, bureaucrats and constituencies, is also taken into consideration,[16] government deep involvement may not only do little to correct "market failure," but it may also create "white elephants."[17]

To cope with this challenge, the competition and cost sharing principles are widely adopted in many countries and even in international bodies like EC Commission to support industrial R&D at arm's length. In real practice, however, there are many limitations, imposed by "bounded rationality" and threat of "opportunism." But the experience in many countries shows that this funding strategy seems advisable in the sense that it helps guide industrial R&D in the direction of national importance and ingrains intrinsic incentive and responsibility sense in the subsidized firms. Though far from perfect, this rather simple funding strategy may become a starting point for more delicate financing designs in the future.

Notes

1 A better selection comes from a wider variety is advocated in Nelson and Winter (1982).

2 Using competition to reduce opportunism is one of the main arguments by Williamson (1975).

3 This is a different interpretation made by Keck (1988).

4 Williamson (1975).

5 This is Dutch experience expressed in an interview in Hague in November 1989.

6 This is confirmed in interviews concerning EC programs in Brussels in December 1989.

7 This is based on interviews with program leaders or coordinators in Nordic countries in April and May 1989.

8 See, for example, Anchordoguy (1988), p. 221 and Nelson (1984), pp. 45-47.

9 This rationale is confirmed in the Nordic countries, the Netherlands, the U.K., EC Commission, etc. in several interviews in April, May, November and December 1989.

10 "Bounded rationality" refers to the cognitive and computational limits of human actors. As a result, individuals face limits in formulating and solving complex problems, processing information, and anticipating the consequences of their own decisions. See Simon (1957).

11 Bloom (1984), pp. 64-70, 76-80.

12 OTA (1983), p. 417.

13 The Fifth Generation Computer Program has been widely discussed. Succinct analysis can be found in Bloom (1984), pp. 71-72; Levy and Samuels (1989), pp. 66-68; Anchordoguy (1989), pp. 188-189.

14 Levy and Samuels (1989), p. 64.

15 Keck (1988).

16 For "government failure" see Wolf (1979).

17 "White elephants" refer to projects which fail the initial expectation of a practical value greater than cost, or more precisely, opportunity cost.

Bibliography

Anchordoguy, Marie (1988), *Computers Inc.: Japan's Challenge to IBM*, Cambridge, MA: Harvard University Press (forthcoming).

Bloom, Justin L. (1984), *Japan's MITI as a Policy Instrument in the Development of Information Technology*, Cambridge, MA: Harvard University Center for Information Policy Research.

Keck, Otto (1988), "A Theory of White Elephants: Asymmetric Information in Government Support for Technology," *Research Policy*, Vol. 17, pp. 187-201.

Levy, Jonah D. and Samuels Richard J. (1989), "Institutions and Innovation: Research Collaboration as Technology Strategy in Japan," MIT MIT-Japan Science and Technology Program Working Paper 89-02.

Nelson, Richard R. (1984), *Hight-Technology Policies: A Five-Nation Comparison*, Washington, D.C.: American Enterprise Institute for Public Policy Research.

Nelson, Richard R. and Winter, Sydney G. (1982), *An Evolutionary Theory of Economic Change*, Cambridge, MA: Belknap Press.

Simon, Herbert A. (1957), *Administrative Behavior*, 2nd edition, New York, NY: MacMillan.

OTA (U.S. Congress Office of Technology Assessment) (1983), *International Competitiveness in Electronics*, Washington, D.C.: U.S. Government Printing Office.

Williamson, Oliver E. (1975), *Markets and Hierarchies: Analysis and Antitrust Implications*, New York, NY: Free Press.

Wolf, C.jr. (1979), "A Theory of Nonmarket Failure," *Journal of Law and Economics*, Vol. 22, pp. 107-139.